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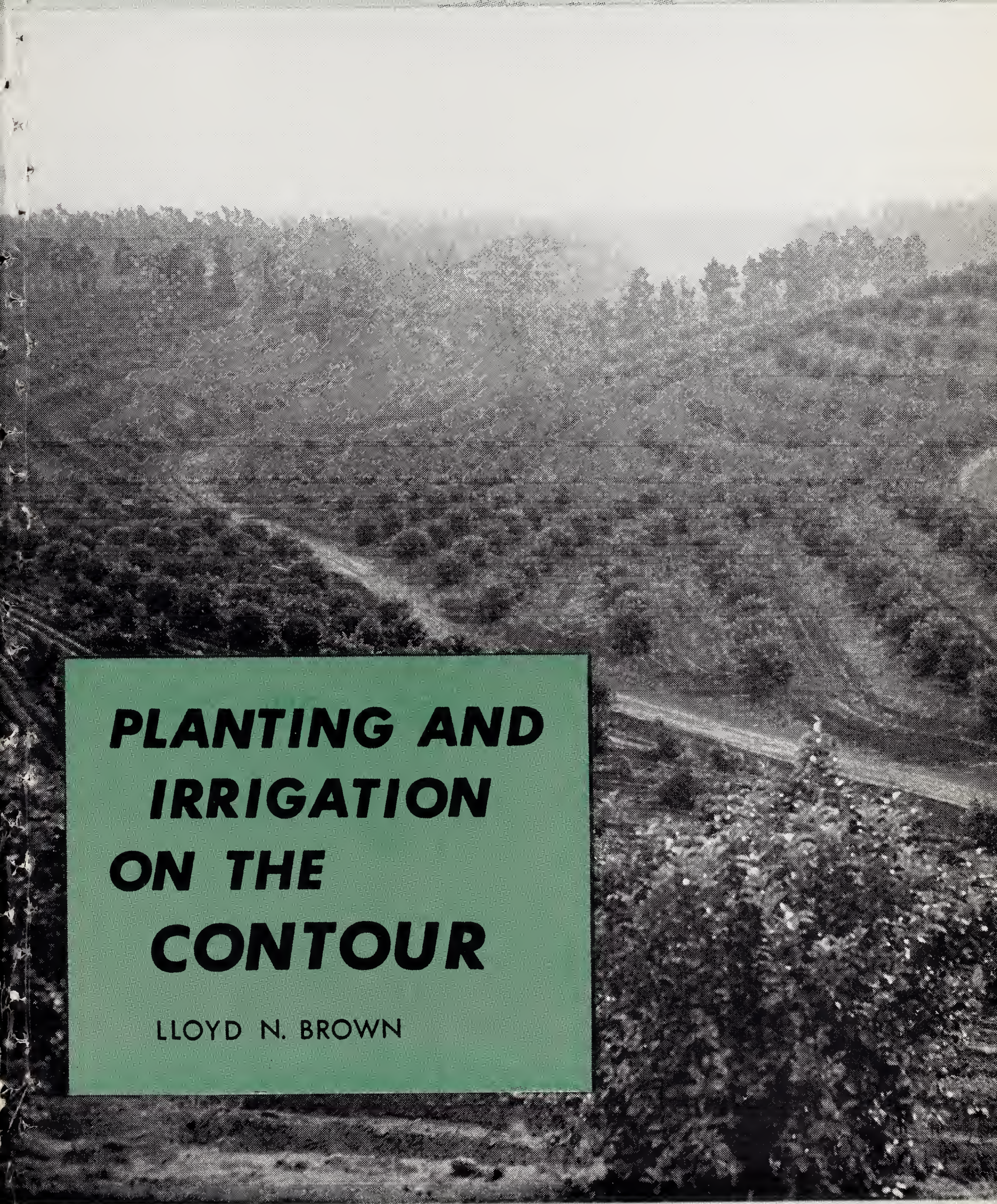

PLANTING AND IRRIGATION ON THE CONTOUR

LLOYD N. BROWN

CALIFORNIA AGRICULTURAL
Experiment Station
Extension Service

CIRCULAR 523

CITRUS planted and irrigated on the contour, Las Posas Orchard, at Somis, California.

THIS CIRCULAR TELLS

- how plants, soil, and water depend on each other
- why contour irrigation is practical, even on steep slopes
- how to lay out a contour planting, particularly one designed for a small acreage.

THIS CIRCULAR DOES NOT ATTEMPT to furnish complete information on laying out contour planting under difficult conditions. University of California Farm Advisors can direct you to a competent engineer for advice on such problems.

A CONTOUR GRADE is the per cent of slope of a contour irrigation furrow. Grades vary, for reasons described in this circular, from ½ foot to 3 feet per 100 feet of length.

CONTOUR FURROW IRRIGATION implies irrigating a crop planted on the contour. Therefore, contour planting is essentional to contour irrigation.

SLOPES discussed in this circular are those too steep to permit successful use of ordinary irrigation methods, such as borders, basins, and straight furrows. Such slopes are often called "moderate-to-steep."

AUGUST, 1963

This publication replaces Circular 440, "Contour Planting and Irrigation on Moderate-to-Steep Slopes," by Lloyd N. Brown, September, 1954.

LLOYD N. BROWN

PLANTING AND IRRIGATION ON THE CONTOUR

ENABLES YOU TO

- **use steep slopes otherwise unsuitable for irrigation**—it makes possible the use of steep slopes which could not be irrigated properly with any other method except sprinklers. Irrigating on the contour allows water to flow slowly in furrows that cross the slope on gentle grades.

- **avoid serious soil erosion**—since the furrow grade is calculated according to the texture of the soil, the danger of furrow erosion is minimized.

- **use irrigation water more efficiently**—since irrigation water runs deep on gentle furrow grades, its percolation into the soil is much greater than that of shallower water running in steep, straight furrows. Water use is therefore more efficient.

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MOST OF CALIFORNIA's good flat lands have been put to use. Intensive agriculture is now literally "taking to the hills," and contour planting and irrigation are providing an effective way of using this steeper, hilly land.

Contour planting and irrigation is widely used by southern California citrus and avocado growers. Outstanding examples of such plantings can be seen in Ventura County, where the system has long been used by citrus growers. The practice is also employed to a limited extent throughout California by growers of bushberries, deciduous fruit, and vegetable crops such as cantaloupes and tomatoes. Practically all strawberries are planted on a slightly modified contour system.

Planting and irrigation on the contour grade could be applied profitably to other hilly or sloping areas of California, with almost any kind of crop.

Before attempting any kind of irrigation it is important to know certain fundamentals. This is particularly true for the difficult practice of irrigating steep slopes.

WATER IS STORED IN THE SOIL

Soil acts as a reservoir to store irrigation water. Therefore the soil occupied by the plant roots should be filled to field capacity. Plant roots take from one to several weeks to deplete the stored water to the *permanent wilting percentage.*

Soils vary greatly in the amount of water they will hold at field capacity. When soil particles are small there are more water-holding surfaces per unit of volume than when the particles are larger. Fine soil will therefore hold more water than coarse.

For example, loam holds about twice as much water as sand; clay holds about twice as much as loam. If we call the capacity of sand 1, loam will be 2 and clay 4. In terms of weight, sand holds about 7% of its dry weight in water, loam about 14%, and clay about 28%.

> The following are terms frequently used in this circular:
>
> FIELD CAPACITY: The quantity of water that soil will hold a day or two after irrigation, when the water has freely moved downward and horizontally.
>
> PERMANENT WILTING PERCENTAGE: The point at which soil has insufficient moisture to prevent plants from wilting.
>
> ACRE-INCH: The amount of water that will cover one acre one inch deep—equivalent to a one-inch rainfall.
>
> PER CENT SLOPE: The fall or rise of land in feet per hundred feet of horizontal distance.

The moisture in the soil which can be considered readily available to the plants is the difference between the field capacity and the permanent wilting percentage (PWP). The PWP is usually about half the field capacity. Occasionally, however, the PWP may be as much as four-fifths of the field capacity, in which case more frequent irrigations are needed. Some red soils of the Sierra Nevada foothills have this narrow range between PWP and field capacity.

IRRIGATION FREQUENCY DEPENDS ON SOIL TYPE

Because of these different water-holding capacities, you should water sands about twice as often as loams and loams twice as often as clays. This will keep water available to the roots at all times. Applying this principle to a field or orchard, you should plan to start irrigating soon enough so that (when several days are required for the complete job) the last plants to be irrigated will receive water before they wilt.

Some plants, such as young corn and lettuce, have sparse root systems which do not occupy the whole soil mass. Therefore frequent, light irrigations are necessary to maintain a supply of moisture immediately adjacent to the roots.

WHEN TO START IRRIGATING

Timing the first irrigation depends on how much moisture has been supplied by winter and spring rains. A light winter rainfall which fails to wet the entire root zone will make earlier irrigation necessary.

In the case of annual crops, the soil should usually be irrigated before planting.

Orchards follow a pattern in their use of water. In deciduous orchards, use is

low in spring, reaches a peak in summer, and drops in fall. Citrus, being an evergreen, uses more water in winter than deciduous trees. Both types reach peak use in July and August.

Irrigation water penetrates the soil a definite distance. The area penetrated—downward and horizontally—is then at field capacity, and the moisture content of adjacent soil remains unchanged.

An ideal irrigation should wet all of the soil occupied by the plant roots; hence furrows should be spaced close enough to wet all the soil.

Don't overirrigate. Over-irrigation wastes water and may harm plants.

Frequently soils which are contour-planted are of limited depth, underlain by bedrock, hardpan, or claypan. Over-irrigation may cause water to collect on these impervious layers, thus creating moisture conditions in excess of field capacity.

Root-rot in avocado groves and gummosis in citrus trees may be caused by such excess water.

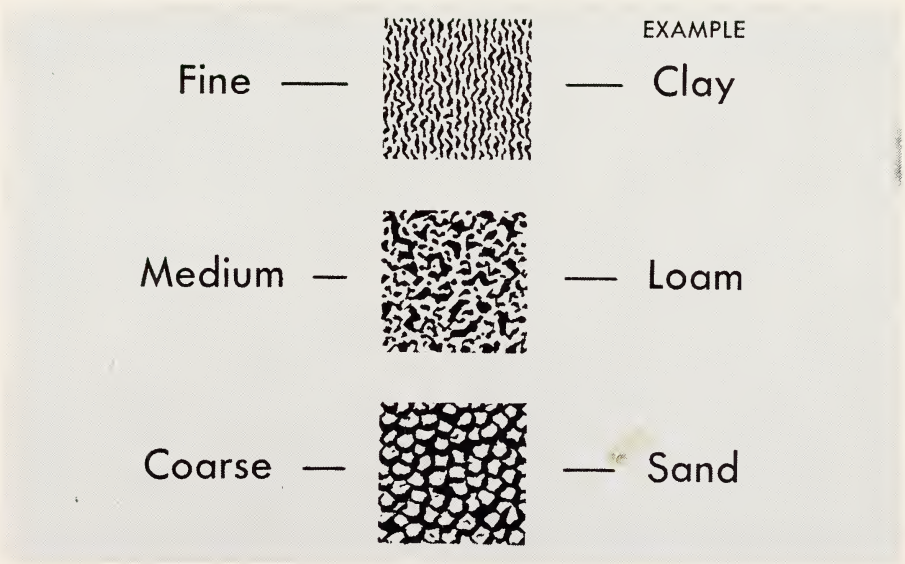
When irrigation water contains large amounts of soluble salts, however, some overirrigation is desirable. Repeated use of such water can cause an accumulation of salt harmful to plants. A heavy irrigation is then necessary to carry the salts below the root zone.

Tensiometers. Until recently soil moisture conditions in the root zone have been determined by the use of soil tubes, augers, and excavation. During the past few years tensiometers have been developed to measure the available water held by the soil. With careful use they are reliable and practical. University of California Farm Advisors can advise you on their use.

WATER NEEDS OF ORCHARDS

MONTH	INCHES OF WATER *Deciduous*	*Citrus*
March	0	1
April	1	2
May	3	2
June	5	3
July	6	4
August	6	4
September	3	3
October	1	2
November	0	1

SOIL TERMS USED IN THIS CIRCULAR



IS YOUR LAND SUITED TO CONTOUR PLANTING?

GENERALLY SPEAKING, the best way to determine whether land is suitable for contour planting is to consult local farmers who have used the method. The following characteristics are particularly desirable in land that is to be contour-planted:

SOIL DEPTH MUST BE ADEQUATE

Soil should be deep enough so that leveling operations will not impair its ability to grow a crop. On sloping land the soil is usually shallow: for example, on rolling terrace areas the subsoil is claypan or hardpan, and on hills the soil is commonly underlain by bedrock. If required leveling operations are very extensive, the site is probably not practical for contour planting.

EROSION LIKE THIS is the result of using too steep a furrow grade.

MEDIUM TEXTURES ARE PREFERABLE

Soil should preferably be of a medium texture. Soils such as loams and clay-loams are usually easier to handle and are most productive. Fine soils crack badly on drying and water often breaks out of the furrows. Sandy soils are liable to present a serious erosion problem when furrows break during irrigation or as result of rain.

IS SLOPE SUITED TO OPERATION?

When choosing a site, consider the slope of the land, since contour irrigation and other orchard operations become increasingly difficult as the slope increases. In practice the deciding factor as to whether a slope is usable is whether orchard operations can be performed economically.

Relatively flat slopes can be irrigated on the natural surface. Cultivation and furrowing on intermediate slopes tend to build up moderate terraces. On slopes steeper than 25 or 30% it is usually advisable to build bench terraces (see page 24).

For field crops, vegetable crops, and strawberries the upper limit of slope is 8 to 10%. Steeper inclines can be irrigated, but all cultural practices become increasingly difficult.

DON'T OVERLOOK NEED FOR DRAINAGE

A practical means for draining off excess water must be at hand. This is important in contour planting to avoid erosion. Excess water from rainfall or irrigation can be removed over grass waterways in swales or through concrete pipes with suitable inlets.

DESIGNING A GOOD FURROW SYSTEM

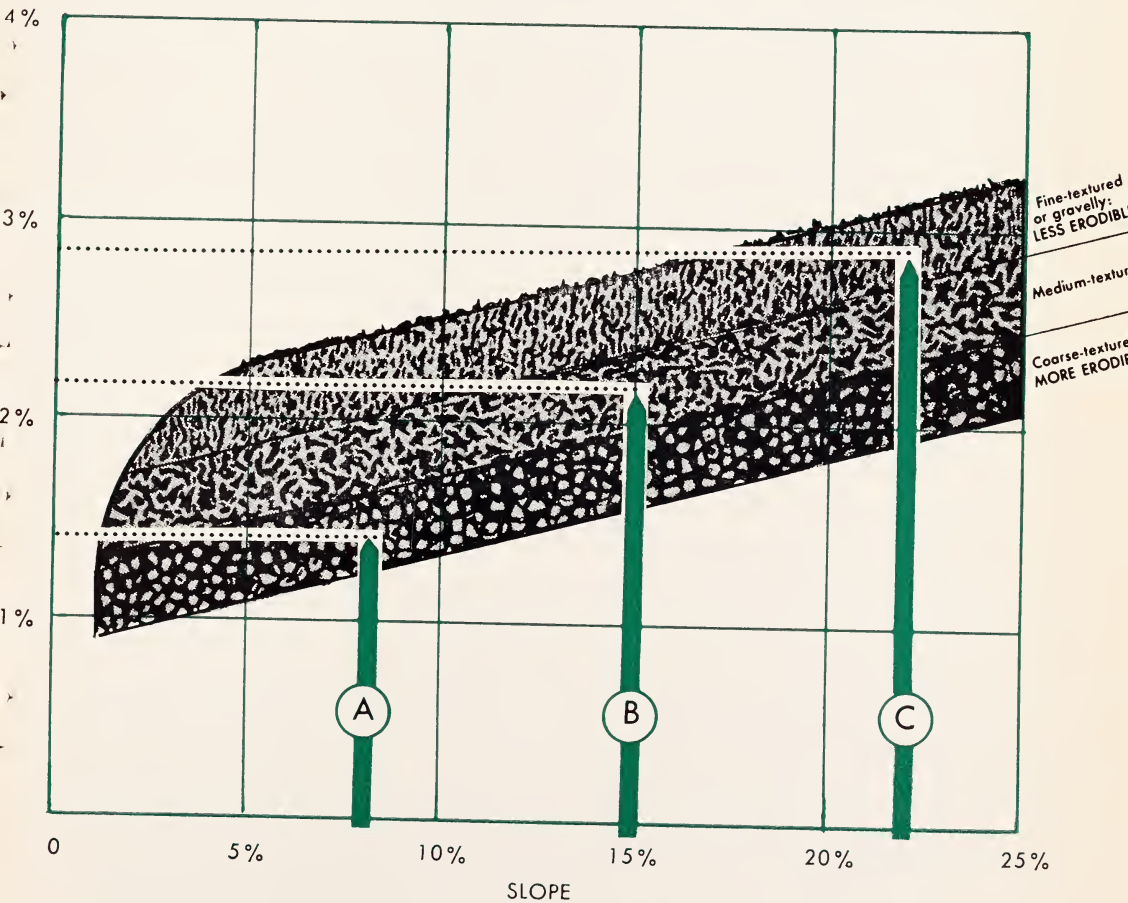
THE IDEAL FURROW SYSTEM would wet all of the soil occupied by the crop roots, with a minimum of tail waste, with avoidance of waterlogging, and with little or no soil erosion.

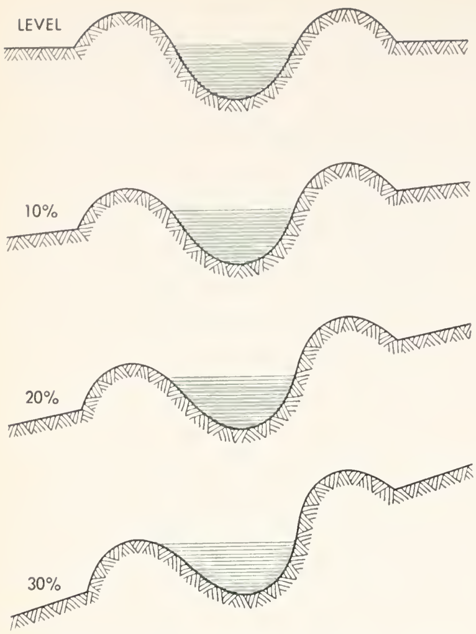
To design such a system, two principal factors must be taken into account: grade of furrow and length of furrow.

HOW TO DETERMINE THE FURROW GRADE

The diagram below shows how two variable elements—soil texture and steepness of the land—affect the choice of the most efficient furrow grade to use in a particular situation. Results obtained will be approximations only.

THIS DIAGRAM WILL help you make a rough estimate of the furrow grade best suited to your land. Example A: You have a piece of land with an 8% average slope and coarse-textured soil. To plant and irrigate on the contour, your furrow grade should be about 1.4%. Example B: Your soil is medium-textured on a 15% slope—your furrow grade should be 2.2%. Example C: Your soil is fine-textured and your slope 22%—your furrow grade should be 2.9%.





AS SLOPES become steeper, the lower side of the furrow is more likely to be overtopped by the water in the furrow. Diagram above shows why the practical limit of slope for this type of furrow is about 20%. Another type of furrow can be constructed by turning the soil down hill only. Such furrows, if carefully constructed and maintained, can be used for somewhat steeper slopes.

Soil texture: Coarse soils erode readily, so grades should be kept fairly flat. Medium soils resist erosion better; therefore intermediate furrow grades can be used. Fine soils are most resistant to erosion; consequently furrow grades may be steeper. Gravelly or rocky soils are also suitable for steeper furrow grades, because as water flows down the furrow it exposes the gravel and rocks on the furrow bottom. This material protects the soil underneath from erosion.

Steepness of land: The stippled part of the diagram on page 7 slants upward from left to right, indicating that steeper slopes require steeper furrow grades. The reason why steeper grades are necessary can be seen in the diagram at left, which shows how irrigation water is more apt to overtop a furrow as land becomes steeper.

Steeper furrow grades compensate for steeper slopes by increasing the velocity of the irrigation water and thereby decreasing its depth.

Occasionally it is impractical to grade land smooth, with the result that it is difficult to lay out furrows on uniform grades. Under these conditions be careful to make the flatter parts of the furrow steep enough to carry the water.

Obviously, the furrow grade should not be increased to the point where soil erosion will be excessive.

MATCH LENGTH OF FURROW TO SOIL

In designing a furrow system it is important to consider how apt your soil is to erode. Long furrows can be used on fine soils but short furrows are necessary on coarse soils because water penetrates coarse soil more easily than fine soil. Fine soil is therefore usually cheaper to irrigate because fewer pipelines are required. (See table below.)

Since water enters coarse soil readily, shorter furrows and extra pipelines are required to avoid losing water through deep penetration and to avoid applying so much as to build up a temporary water table on the subsoil. The expense of extra pipelines may make irrigation of coarse soils on steep slopes uneconomical.

TABLE BELOW shows suggested furrow lengths and irrigation times for different soil textures. Duration of irrigation and length of furrow vary directly with the fineness of the soil.

LENGTH OF FURROW	SOIL	DURATION OF IRRIGATION
200–400 ft.	Coarse	2– 6 hrs.
400–600 ft.	Medium	6–12 hrs.
600–800 ft.	Fine	12–24 hrs.

CHOOSING A PLANTING LAYOUT
THE NEXT STEP . . .

After you have estimated the most desirable grade and length for irrigation furrows, decide on a system of planting.

Contour plantings vary greatly in detail, since each area presents its own problems and each owner has his own ideas. Two principal systems are illustrated in this circular; they are the most widely used in laying out contour plantings.

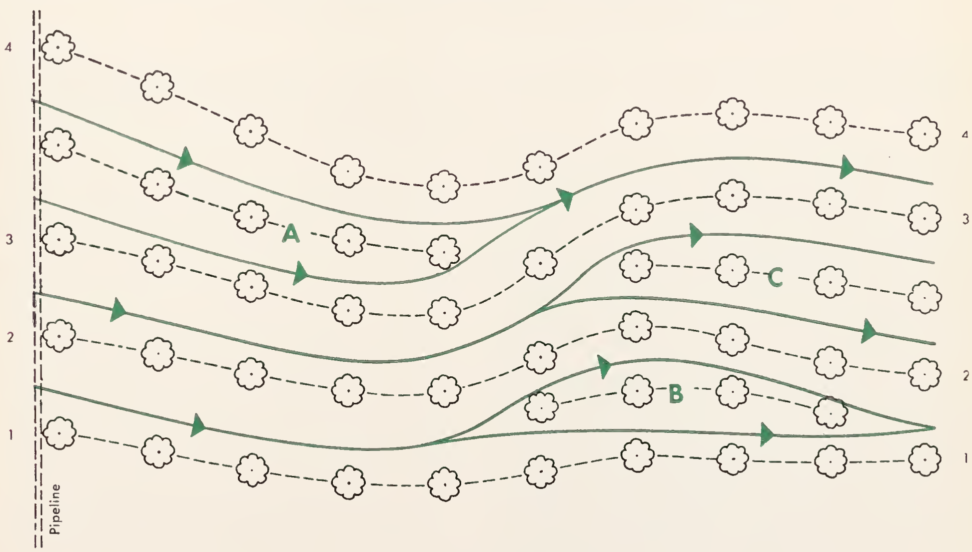
CONTOUR-PLANTING TERMINOLOGY

Before studying planting systems you should become familiar with contour-planting terms. These are illustrated in the diagram below, which shows an orchard laid out with contour rows and straight up-and-down crossrows. Contour rows begin just to the right of the pipeline. Arrows indicate the direction of water flow. Each line may represent several furrows.

Rows 1 and 2 separate noticeably at the right of the sketch. To fill this space a *fill row* (B) is inserted as shown. Likewise a *spike row* (C) is put between Rows 2 and 3. The row that is pinched out between Rows 3 and 4 becomes a *stub row* (A).

TERMS USED IN CONTOUR PLANTING

LINES IN COLOR indicate water flow from pipeline at left. Lines may represent several furrows. Trees connected by dotted lines form contour grade rows, while trees up and down the slope form crossrows. *Stub row* is shown at A; a *fill row* at B; and a *spike row* at C.



THERE ARE TWO PRINCIPAL

Above and at right, the two planting systems applied to the same topography.

SYSTEM I—NO CROSSROWS

SOUTHERN CALIFORNIA citrus orchard is a variation of System I.

SYSTEM I—Uniform spacing of trees along a contour grade without regard to alignment in other direction.

The main advantage of this system is that it is well suited to steep, irregular topography. It usually results in more trees per acre than System II.

Up-and-down hill cultivation cannot be practiced, because there are no crossrows. This is probably an advantage, since such cultivation tends to leave mounds around the trees, thus making irrigation more difficult.

A disadvantage of System I is that broken irrigation furrows are not easy to detect.

ORCHARD LAYOUT SYSTEMS

System II allows fewer trees per acre: above are 65 trees; at left, 73 trees.

SYSTEM II—STRAIGHT CROSSROWS

SYSTEM II—The other main system of contour planting consists of uneven spacing of trees on the contour grade, with straight crossrows.

This planting method usually allows fewer trees per acre and is a little harder to lay out than System I.

An advantage of System II is that, since up-and-down rows are straight, broken irrigation furrows are more easily detected.

Also, the distribution, servicing and operation of orchard heaters is simplified.

Cultivation up and down the slope is possible—but not recommended. It tends to leave trees on mounds.

System II is best suited to smooth, uniform slopes.

EXAMPLE OF System II, with relatively straight crossrows.

THIS UNDERTAKING requires skill and judgment. To obtain good results you should adopt a step-by-step procedure.

First, determine what grade your irrigation furrows should have, following the chart and instructions on pages 13 and 14. This should be done carefully and unhurriedly. You'll find it helpful to examine orchards already planted under conditions similar to those on your land.

EQUIPMENT NEEDED TO MAKE LAYOUT

Next, gather your equipment. Best, but most expensive, would be an engineer's level, rod, and steel tape. Less expensive but harder to use would be a farm level, a cloth tape, and a flexible cloth rod tacked on a 1 × 3 board. A hand level can be substituted for the farm level on small plantings where great accuracy is not necessary. A hand axe, 4-foot stakes, and 16-inch stakes complete the equipment list. (Laths cut in three 16-inch lengths make good stakes.)

On the following pages the directions for laying out a contour-planted orchard are given in text and photographs.

HOW TO START THE JOB

Assume that we are facing a tract of side-hill land. The average slope is 10%; tract width is 300 feet; the pipeline will be near the left margin; land slope at the pipeline is average for the field; and the contour rows are to be about 20 feet apart.

Start the layout in the lower left-hand corner of the field by putting a stake about 6 feet to the right of the pipeline location. From this stake proceed up the hill paralleling the pipeline location and driving stakes every 20 feet. These stakes locate the first tree in each row.

SECOND STEP: LOCATE THE TREE ROWS

Now we are ready for the second step —locating the direction and grade of the tree rows. Set up the level over the first stake. Bring the rod up close to the level and set the target at the same height as the telescope.

Assume that the telescope is exactly 5 feet above the ground. The target would then be set at 5 feet on the rod.

The rodman moves across the slope 50 feet, as measured by the tape. Since the contour grade is to be 2% (2 feet down for each 100 feet across), the rodman slides the target up 1 foot on the rod (because the distance across the slope is half of 100 feet). The reading on the rod then becomes 6 feet, and the rodman moves the rod up or down the slope (as directed by the levelman) until the center of the target is level with the telescope. At this point the rodman puts a 4-foot stake in the ground.

The stake, then, marks a spot 50 feet from the first stake and 1 foot lower in elevation. We now have a start on the desired 2% grade.

The rodman moves out another 50 feet across the slope, raising the target on the rod another foot, and the process of sighting-in and marking with a stake is re-

(Continued on page 17)

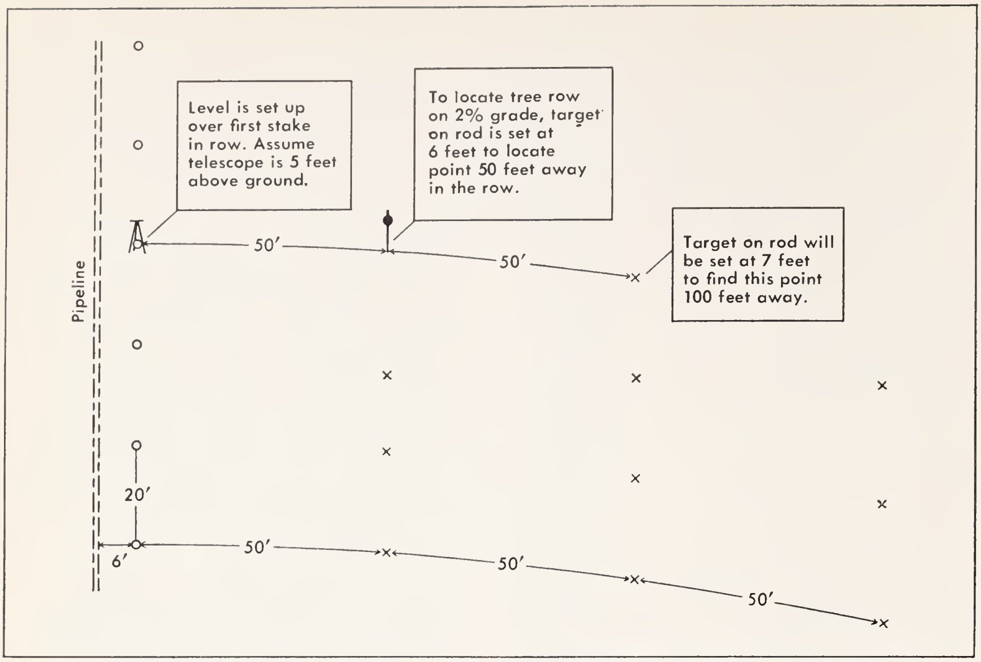
TYPICAL PRICES OF EQUIPMENT (1963)

Builder's level with tripod	$160.00
Farm level with tripod	70.00
Engineer's rod with target	40.00
Flexible rod	4.00
Steel tape (100′) and engineer's reel	45.00
Steel tape (100′) in leather case	35.00
Cloth tape (100′) in leather case	23.00

LEVEL is set up over the first stake, and the target on the rod is set at the same height as the telescope on the level (see photo at right). Stakes locate position of the first tree in each row. Here they are 20 feet apart.

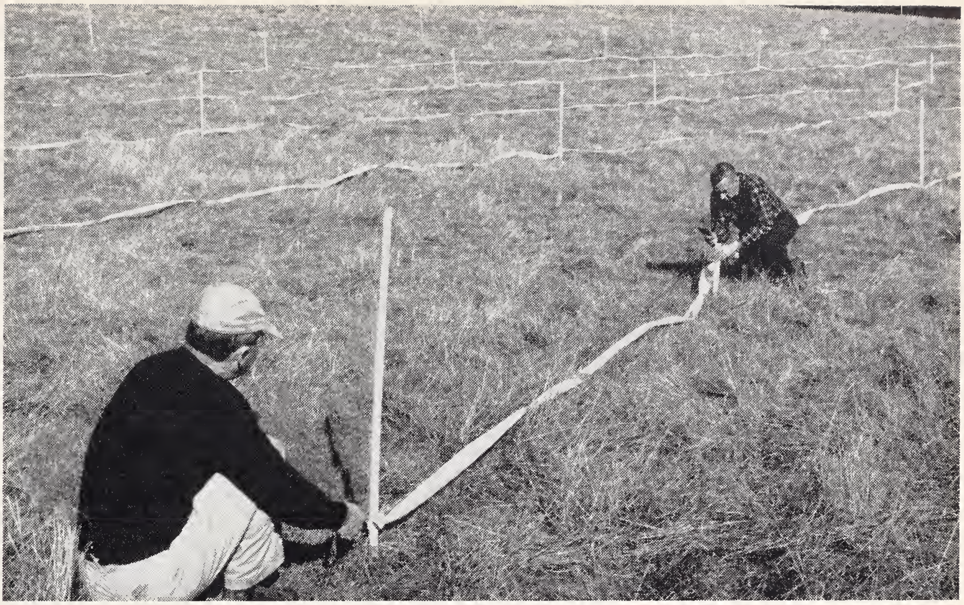
THE ORCHARD LAYOUT OPERATION IN PICTURES

LAYOUT WORK STARTS at first stake in lowest row (see photo below). Rodman (at right) has moved about 50 feet, setting target for desired grade. Level operator will direct him to move up or down slope until crosshairs in level coincide with center of target. Rodman will then mark that point with a stake and move out another 50 feet. Location of pipeline is indicated by the white markers parallel to the line of stakes.



DIAGRAMMATIC representation of the orchard layout operation shown in the photographs that follow. The level and rod settings are assumed.

RODMAN has now moved 150 feet from level, setting stakes every 50 feet. When all rows have been staked out, the next step (above right) is to mark positions of trees in rows.



ONE MAN holds tape at stake marking position of first tree (at left), while other man drives stake 20 feet away. The paper strips have been laid out merely to show the location of the tree rows and, in this instance, as an aid in locating tree positions. However, in actual layout work paper strips are not used. The tree stakes are located on the tree row as indicated by the 4-foot stakes. When all the tree stakes in a row have been located, it may be necessary to move some of them a few inches up or down the hill in order to smooth the curve of the tree row.

SYSTEM I LAYOUT . . .

TREE-POSITION stakes have now been driven (the longer grade marker stakes having been removed). Note the staggered effect of the stakes, resulting from the uneven spacing of stakes in the rows. This illustrates a System I layout.

TO LAY OUT an orchard according to System II (straight crossrows), set out two parallel rows of stakes, evenly spaced according to the distance desired between tree crossrows, as in photo below at left.

SYSTEM II LAYOUT . . .

WHILE ONE MAN sights between corresponding stakes in top and bottom rows, other man drives tree-position stakes in the grade rows (photo at right).

(Continued from page 12)

peated. Each stake in the contour row locates a point 1 foot lower than the preceding one. Thus a line of stakes is established across the slope indicating a 2% grade.

The practice of driving stakes every 50 feet is recommended for average conditions. When the cross-slope line makes curves sharper than normal, stakes may be needed every 25 or even every 10 feet, to give an accurate line. When this is necessary, the rodman adjusts the target to compensate: For stakes 25 feet apart he would move the target one-half of a foot (6 inches); for stakes 10 feet apart he would move the target one-fifth of a foot (2⅜ inches).

When the rodman reaches a point about 300 feet away from the level operator or when he is about to disappear from view around the side of the hill, the level operator should move up to the last accurately marked point and set up the level over that point. The process of sighting-in is repeated from there.

The line of stakes is extended as far as it is desired to plant trees. Then the level is brought back to the pipeline, set up over the stake marking the next row uphill, and the staking process is repeated. Each row is done in the same way, until the rows are all marked out.

STUB, FILL, AND SPIKE ROWS

Because of unevenness in topography, the rows will not run exactly parallel to each other. When any row is found to run within less than 18 feet of another row, it should be discontinued; go back and start the next row. The incompleted row is called a *stub row*.

When rows separate more than 35 feet, finish the row being worked on, then come back and lay out a row between the two. This is known as a *fill row*.

If rows diverge at the far ends, a *spike row* can be inserted in the same way as the fill row.

When the rows have been staked out, the spots where trees are to be planted will be marked with 16-inch stakes.

TREE LAYOUTS FOR SYSTEMS I AND II

Laying out orchards according to the two planting systems described previously (pages 10–11) calls for two slightly different procedures.

Under System I the trees are to be planted at equal intervals along the contour grade row; hence the only problem is to space the tree-marker stakes equally.

Under System II the trees are to be planted at such intervals along the contour grade row as will result in straight crossrows. To achieve straight crossrows, you will need *guide lines* so that you can align the trees up and down the slope. After you have staked out the row locations, you set up two guide lines at right angles to the pipeline—one near the lower edge of the field, the other near the upper edge. Four-foot stakes are driven at the desired tree-spacing intervals to locate the crossrows. Now, by sighting along the first stakes in each guide line, tree positions can be located on each contour grade line. Other tree locations are aligned in straight crossrows in the same manner.

HOW TO LOCATE TREES WITH A GRADE BOARD

A grade board (page 18) is a simple device which may be used instead of a level, rod, and tape to locate the positions of trees on a contour.

The board should be as long as the desired distance between the trees that are to be planted in the orchard—for example, 20 feet. One end of the board has a fixed, unmovable leg; the other leg is adjustable. The board must be completely rigid over its 20-foot length.

The short leg may be of any convenient length—say 12 inches. The adjustable leg may then be set to give any desired grade or rate of fall. For trees spaced 20 feet apart on a 1% grade, the adjustable leg should be made 14⅜ inches long.

GRADE BOARD being used to locate positions of trees. Short leg is held at position of first tree in the row; end of board with long leg is moved up or down the slope until the level bubble is centered. The point where the long leg comes to rest is marked with a stake. This will mark position of second tree.

LOCATING TREES WITH A GRADE BOARD

OPERATORS set up third tree position in row. Others are staked out in similar manner.

Here is how we arrive at the length of $14\frac{3}{8}$ inches: On a 1% grade a 100-foot row would have a fall of one foot or 12 inches. A 20-foot grade board is $\frac{1}{5}$ of 100 feet in length. Therefore, in a 20-foot grade board the fall would be $\frac{1}{5}$ of 12 inches or about $2\frac{3}{8}$ inches. Thus the adjustable leg would be 12 plus $2\frac{3}{8}$ or $14\frac{3}{8}$ inches long.

Now that the grade board is adjusted, how do we use it? The first tree in each row is located—as before—by a stake about 6 feet from the pipeline. Place the short leg of the grade board next to the stake. The other end extends in the approximate direction of the row. Now move the adjustable end of the board up or down the slope until the level bubble is centered. Place the second stake at this point to indicate where the second tree will be, and continue with the same procedure for the remaining tree locations.

This method of locating trees will result in an orchard without straight cross-rows.

PLANTING BOARD PUTS TREES WHERE YOU WANT THEM

Having gone to the trouble and expense of marking the exact points at which trees are to be planted, you can "protect your investment" by using the planting board. This board insures that trees will be spotted exactly where the markers indicate they should be placed.

The photos at right illustrate how a planting board is used.

ABOVE, TOP, notch in middle of planting board is placed against tree-marker stake and additional stakes are driven into notches at either end of the board.

CENTER STAKE and board are then removed and hole dug for the tree, as shown in photo at right. Planting board is replaced and tree positioned in center notch for planting.

OTHER PUBLICATIONS ON RELATED SUBJECTS

IRRIGATION

Essentials of Irrigation and Cultivation of Orchards. Frank J. Veihmeyer and Arthur H. Hendrickson. California Agricultural Experiment Station—Extension Service Circular 486, revised February, 1960.

COVER CROPPING

Elimination of Tillage in Citrus Soil Management. J. C. Johnston and Wallace Sullivan. Extension Circular 150, March, 1949.

THERE ARE TWO reasons why you should cultivate only when absolutely necessary: First, if cultivation isn't necessary it is a waste of time, money, and equipment. Second, if the soil is wet, cultivation tends to pack down the earth beneath the layer cultivated, causing water penetration to be impaired and sometimes even hampering root development.

However, here are four important reasons why orchard cultivation may be desirable:

- To control weeds or annual pests.
- To prepare land for irrigation.
- To plant a cover crop.
- To work in a cover crop.

THREE COVER CROP AND CULTIVATION SYSTEMS

Three systems relating to cover crops and cultivation are most common.

1—Winter cover crop, summer tillage: This system is practiced under many soil and climatic conditions. A cover crop is established each fall to prevent erosion by winter rains. Often it is necessary to fertilize the crop for adequate growth. In spring, the crop should be worked into the soil to keep it from competing with the trees for moisture and to permit installation of new furrows.

2—Permanent cover crop, no tillage: Under this system, furrows are installed and the crop allowed to grow over the entire surface. Results with this method vary greatly. Consequently it is praised and condemned with equal vigor. In any case, it takes great skill and should be used only after careful study.

Advantages:

The system effectively controls soil erosion.

It gives best results on deep and permeable soils.

Disadvantages:

Rodents in the crop are hard to control; they may injure trees by gnawing bark from the tree near the ground level.

The system permits growth of undesirable and difficult-to-control plants such as Bermuda grass.

Additional water is needed for the cover crop.

The cover crop can cause fertility problems.

The cover crop may grow so large it hinders operations. And the dry material, after mowing, can be a fire hazard.

3—No cover crop, no tillage: Weed control with oil and chemical sprays has, in recent years, focused attention on this practice which is spreading rapidly in citrus areas and is being used experimentally in deciduous orchards.

An advantage of this system is that the soil usually becomes more porous, thus facilitating irrigation. On the other hand, shorter furrows, requiring extra pipelines, become necessary to avoid wasting water through deep percolation.

Weed-control expense is high for several years but then tapers off.

DON'T CULTIVATE IN CROSSROWS

Steep orchards should be cultivated on the contour—not up and down hill. Implement marks up and down hill encourage soil erosion.

When contour cultivation alone is continued on steeper slopes, bench terraces tend to form. Then, if up-and-down cultivation is started, trees are often left on mounds. The resulting uneven ground surface makes irrigation difficult. This can also cause serious erosion from winter rains because runoff is concentrated in low spots.

BUSHBERRIES ON THE CONTOUR

In the coastal region of central California a large area of trellised bushberries is irrigated by contour-grade furrows. The plantings are usually on gently rolling land sloping not more than 8%. Grade of rows is about 1%. Since the topography is smooth it is not necessary to use stub, spike or fill rows to any great extent.

In these plantings the distance between the rows is about 8 or 10 feet. Field operations are generally performed with tools which make only one trip per row. With such a narrow row sharp curves should be avoided as they may impede use of equipment.

Where a tractor with tools attached is to be used, curves may have a radius as short as 20 feet. But when the tools are pulled behind the tractor the curves should have a radius of not less than 30 feet. Try out your tractor and tools first, to see how sharply they can turn in the distance between rows you propose to plant.

In irrigated vineyards, contour planting is not common, but the practice has merit where the land is steep enough to present a soil-erosion problem.

VEGETABLES ON SLOPES OF 8 TO 10%

Most vegetable crops are raised on flat bottom land. Some farmers, however, have grown vegetable crops on land slop-

BUSHBERRIES planted on a contour grade.

ing as much as 8 to 10%. Grades of rows seldom exceed 0.5%. Flatter grades are used because the soil surface is bare and is cultivated frequently. These conditions render it very susceptible to soil erosion.

Higher lands often have the advantage of being more frost-free than bottom land. Also, south and west exposure are noticeably warmer in winter.

Disposal of waste water from irrigation and rainfall is a serious problem in growing vegetables on the contour. Uncontrolled, such water may cause serious gullying.

One of the best control methods is to establish a grassed waterway for the waste water. Build a wide, shallow ditch and seed it with rye grass or other sod-forming plant. On steep grades it may be well to cover the newly seeded ditch with straw and lightly disk it. Irrigate the ditch carefully until a good stand is obtained. After that there should be little or no erosion. Lined ditches or concrete pipelines are sometimes used, but these involve substantial cost.

STRAWBERRIES RAISED ON ROLLING LAND

Large acreages of strawberries are raised on rolling land, usually on slopes of less than 6%.

The soils frequently have a dense claypan not more than two feet below the surface. Since the soil is shallow, leveling must be limited.

Laying out a commercial planting on such land is usually done by an expert.

In strawberry plantings, growers prefer rows that are straight, about 125 feet long, and level. These three conditions can be met on suitable land without much leveling, although ingenuity and skill may be needed.

THIS TYPICAL STRAWBERRY planting on sloping land has a wooden flume in the center of the field unit to supply water. The level rows are irrigated both ways from the flume to the roads at the edges of the field. Since the rows are level the furrows between them are really long, narrow basins which fill at each irrigation. There is no run-off after irrigation or rain and therefore no waste or soil erosion. Slope of the field is about 6%.

LEVEL FURROWS in strawberry field stand full of water just after irrigation. Furrows act as basins; no water is wasted.

DIVERGING FURROWS in strawberry field indicate that a change in furrow direction was necessary to keep furrows level without much land leveling. Irrigation water comes from flume in foreground.

BENCH TERRACES are frequently used on citrus plantings such as shown above and below. Contour grade rows are laid out as described in text. Next, bench terraces are made, with the bench sloping slightly toward the hill. Tree rows are then staked out near the margin of each bench.

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